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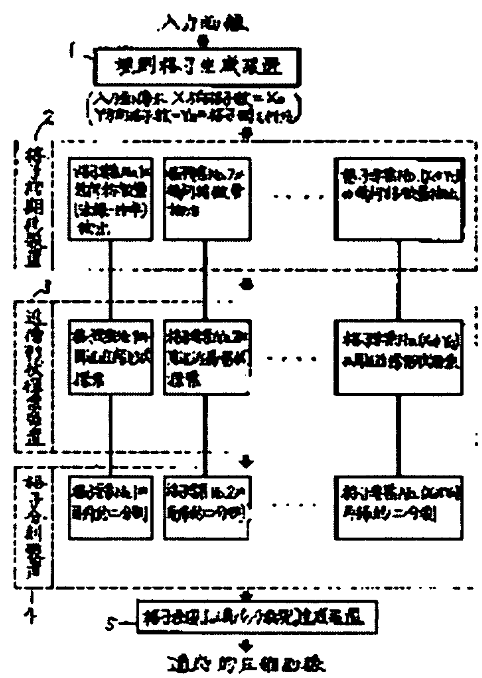
(54) ADAPTIVE AND HIERARCHICAL GRID EXPRESSION GENERATING DEVICE FOR IMAGE

(57)Abstract:

PURPOSE: To adaptively compress and restore the image by using a means which generates adaptive grid expression as to the whole image on the basis of its geometrical characteristics.

CONSTITUTION: A rule grid generating device 1 define a square rule grid surface for the input image and a grid initializing device 2 initializes the grid surface and the data structure of respective grid elements. A nearby shape search device 3 makes a recursive search for shape variation of a peripheral nearby area of each grid element in an 'outward direction' and a grid dividing device 4 recursively divides grid elements in an 'inward direction' from the borders of the respective grid elements. A grid expression generating device 5 generates the grid expression of the input image from the respective recursively divided grid elements.



LEGAL STATUS

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CLAIMS

[Claim(s)]
[Claim 1] A grid initialization means to set up an input image in respect of the initial superlattice set up by grid width of face level, at equal intervals, and perpendicularly unacquainted, It is based on the geometric characteristic quantity of the pixel value in each lattice point location set up by said grid initialization means. A hierarchical grid expression generation means which generates an accommodative and hierarchical grid expression to divide a lattice plane recursively and to reflect the geometric description of an image, its continuity, and discontinuity faithfully, And accommodative and hierarchical grid expression generation equipment of an image equipped with a means to search for the geometric description change near the circumference recursively in order to avoid the clearance between the approximation polygons which generate the lattice plane generated by said hierarchical grid expression means in the process divided accommodative.

[Translation done.]

* NOTICES *

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to accommodative accommodative and hierarchical grid expression generation equipment of an image of an image which is used for technical fields, such as CAD modeling of the arbitration configuration body aiming at the picture compression which belonged to the field of a computer vision or computer graphics especially, carried out the triangular patch expression of those common images, such as distance, a shade, and a color picture, using the technique of an image processing, and carried out the purpose of the pictorial communication about hierarchical grid expression generation equipment and restoration, and a graphics display.
[0002]
[Description of the Prior Art] Compression and restoration of the conventional image have the common technique based on the frequency analysis of an image. However, from computational complexity-constraint, since the frequency analysis for the whole image is difficult, it processes by dividing an input image into two or more rectangle fields (block). However, the problem by which the continuity of the analysis result during a block is spoiled is produced.
[0003] The technique of using a grid expression, and on the other hand, compressing and (sampling) restoring an image in a computer vision in recent years or the field of an image processing, has been proposed. As an approach of generating an adaptation grid expression, the approach of moving each lattice point location of a superlattice, and the approach of correcting the number of the lattice points and connection relation are mentioned. The technique of moving the lattice point takes great computation time, in order for far-reaching lattice point migration to take place and to obtain the grid expression of a uniform precision on all front faces, when the formation of a form status change on the front face of an object is uneven. Moreover, the connection relation of a during [the existing lattice point] was often spoiled, and the technique of fluctuating the lattice point had the trouble of a crack (clearance) occurring in the approximation polygon obtained from a grid expression.
[0004] So, the main purposes of this invention are accommodative and offering [of the image which uses a means to generate an accommodative grid expression based on that geometric property for the whole image, and can compress and restore an image accommodative] hierarchical grid expression generation equipment.
[0005]
[Means for Solving the Problem] A grid initialization means to set up an input image in respect of the initial superlattice set up by grid width of face level [this invention], at equal intervals, and perpendicularly unacquainted, It is based on the geometric characteristic quantity of the pixel value in each lattice point location set up by the grid initialization means. A hierarchical grid expression generation means which generates an accommodative and hierarchical grid expression to divide a lattice plane recursively and to reflect the geometric description of an image, its continuity, and discontinuity faithfully, In order to avoid the clearance between the approximation polygons which generate the generated lattice plane in the process divided accommodative, it has a means to search for the geometric

description change near the circumference recursively, and is constituted.
[0006]
[Function] The polygon approximation expression of that the image concerning this invention is accommodative and the highly precise image which hierarchical grid expression generation equipment generates an accommodative grid expression by the recursive call of a brief division procedure, and does not have a lattice point set and its connection relation to a clearance is generated in high-speed partial parallel operation under time / spatial limit.
[0007]
[Example] Drawing 1 is the outline block diagram of one example of this invention. In one example of this invention, an object image is made into the depth map gained with a laser range finder etc., and 3D curvature (max and the minimum principal curvature) computed using primary [of a pixel value] and quadratic differential as that geometric description is used.
[0008] drawing 1 -- setting -- superlattice generation equipment 1 -- an input image -- the number of the direction grids of X -- =X0 and the number of the direction grids of Y -- =Y0 A square superlattice (field) is defined. Grid initialization equipment 2 initializes the DS of the defined grid (field) and each grid element. Configuration retrieval equipment 3 will search for form status change-ization of the field near the circumference of each initialized grid element recursively soon in "the direction of an outside (it carries out asymptotic to a field boundary line)." Grid division equipment 4 divides a grid element recursively from the boundary of each grid element based on the result for which it searched in "the direction of the inside (it carries out asymptotic to a grid element core)." Grid expression generation equipment 5 generates the grid expression (triangular patch expression) of an input image from each grid element divided recursively.
[0009] Drawing 2 is drawing showing the two-dimensional array of the tetragonal lattice element of initial grid width of face. Next, initialization and the layered structure of a grid are explained with reference to drawing 2 . The grid (field) into which an input image is first divided by superlattice generation equipment 1 the first stage using a square superlattice (field) serves as a two-dimensional array of the tetragonal lattice element of initial grid width of face, as shown in drawing 2 (a). Grid initialization equipment 2 initializes each grid element. each grid element -- four sides of a grid element -- each -- it consists of binary tree structures of the root triangle Tri of four pieces [i] made into the machine side, i= 0, and 1, 2 and 3. Each binary tree shown in drawing 2 (b) shows the layered structure of the shape of toothing in each root triangle (curved-surface field made into a boundary) of a grid element. With each root triangle, "the curvature level n0" is set up from the magnitude of the curvature value in the distribution curve and 3 grid endpoint of a curvature value on [all] a front face.
[0010] Drawing 3 is drawing showing the condition that the crack occurred in the approximation polygon obtained from a grid expression. Next, retrieval of the configuration near recursive is explained with reference to drawing 3 . The near configuration retrieval equipment 3 shown in drawing 1 judges the need for grid division from the result of having searched for the configuration recursively in the direction of the circumference soon, in order to avoid that a crack occurs in the approximation polygon obtained from a grid expression, as shown in drawing 3 . Let the leaf (end) triangle of the binary tree of each grid element be a current parent triangle. the case where, as for a parent triangle, the conditions of following ** - ** are satisfied either here -- left part and the right-hand side -- each -- it is halved by the right-and-left child triangle made into the machine side.
[0011] ** Curvature level Kp which met the machine side It is larger than the current division depth n (hierarchy of a binary division tree).
[0012] ** Curvature level Kl in alignment with the right-hand side It is larger than the current division depth n+1.
** Curvature level Kr which met left part It is larger than the current division depth n+1.
[0013] The conditions of ** are immediately judged among three above-mentioned conditions. however -- until, as for the judgment of the conditions of ** and **, the conditions of ** are satisfied -- the left part of a parent triangle, and the right-hand side -- each -- it considers as the machine side, a right-and-left child triangle is defined, and it is carried out based on the result of having searched for the

configuration recursively soon.
[0014] The distance d from **** of a root triangle to the tip of the near seek area of the retrieval (recurrence) depth n is given by the following ** (1) formula.
[0015]
[Equation 1]

$$d = \sum_{i=1}^{k} (\text{InitquadSize}) \times (1/2))^{i} < \text{InitquadSize} \qquad \cdots (1)$$

[0016] However, k= [n/2] and InitQuadSize are initial grid width of face. Drawing 4 is drawing for explaining the near retrieval range required in order to divide each grid element. Since the above-mentioned distance d is given by asymptotic series, the upper limit of retrieval distance does not exceed initial grid width of face. Therefore, the near retrieval range required in order to divide each grid element can be limited in the field of magnitude [being surrounded in the slanting one half of four grid elements which adjoin four sides of ** each grid element, and four grid elements which touch in ** four endpoints each (7(= 5+1 / 2x4) *InitQuadSize2)]. For this reason, it is proved that new lattice point generation within each grid element does not do effect across the above-mentioned near retrieval range.
[0017] The upper limit of retrieval (recurrence) depth is limited by the maximum (first stage) grid width of face and the minimum grid width of face to below the following ** (2) type.
[0018]
dmax <logroot2 (InitQuadSize)-logroot2 (MinQuadSize) -- (2)
However, MinQuadSize It is the minimum grid width of face specified.
[0019] By above-mentioned explanation, the configuration in the limited near field can determine division of each grid element locally completely.
[0020] Drawing 5 is drawing showing the process which forms 2 adjoining grid elements in three hierarchies' binary tree structure. When it opts for division of a parent triangle soon based on the result of configuration retrieval, the grid division equipment 4 shown in drawing 1 generates the new lattice point M at the middle point of ****, and divides it into two child triangles which made **** the left part and the right-hand side of a parent triangle. Furthermore, each right-and-left child triangle is made into a parent triangle, and grid division is repeated recursively. 2 grid elements Qd (i0 and j0) and Qd (i0 and j0+1) which adjoin drawing 5 The boundary line is met. When curvature is high, (curvature level = when set up with 3) The root triangle Tr [0] of Tr [2] of Qd (i0 and j0) and Qd (i0 and j0+1) is divided 3 times recursively, and the process in which three hierarchies' binary tree structure was formed is shown (the generation process of a child triangle is shown in alphabet ascending order).
[0021] Drawing 6 is drawing showing the succession regulation of the 3 lattice points of a parent triangle, and the middle point of **** accompanying generation of a child triangle. When recursive depth of a current parent triangle is set to n, the recursive depth, the **** length, left part length, and right-hand-side length of a child triangle are n+1, ln+1 (= (InitQuadSize* (1/root2)) n+1), and ln+2 n (=InitQuadSize* (1/root2))+2. Whenever the recursive depth of grid division increases once, each side length of four triangular patches of a grid element (quad) is reduced to 1/root2, and the number of triangular patches is increased twice.
[0022] The succession regulation of the 3 lattice points (p0, p1, and p2) of a parent triangle and the middle point M of **** accompanying generation of an equilateral triangle is shown in drawing 6 (a). The changes process of the 1st point (set [about] left end point) of the **** triangle generated according to the lattice point succession regulation is shown in drawing 6 (b). Grid division (recurrence) depth is determined by the curvature level K of ** grid element, the ** maximum (first stage) grid width of face InitQuadSize, and the ** minimum (last) grid width of face MinQuadSize. The upper limit nmax It is expressed with a ** (3) type.
[0023]
nmax <=logroot2 (InitQuadSize)-logroot2 (MinQuadSize) -- (3)
** The maximum (min) grid width of face of ** is equivalent to the magnitude of the maximum

minimum flat surface of an approximation polygon. Therefore, grid division depth is determined by "compression / restoration precision" demanded with the geometric description of an image. By above-mentioned explanation, grid expression (triangular patch expression) generation equipment 5 generates the grid expression (triangular patch expression) of an input image using the triangular patch set in the grid element in which division generation was carried out by the partial parallel operation of O (log n) accommodative with each grid element.
[0024] The adaptation grid generation algorithm by this invention is explained with reference to drawing 7 - drawing 11 about the experimental result generated by C. Two real face depth maps, a male and a woman, were used for this experiment.
[0025] Drawing 7 is drawing showing the condition of having described the configuration of a face image, especially drawing 7 (a) shows a original depth map, (b) shows a geometric characteristic quantity extract result (principal curvature and direction of principal curvature), and (c) shows the field point (root(k1 2+k2 2) > 0.015) that curvature is high.
[0026] Drawing 9 divides recursively the tetragonal lattice element of the initial grid width of face delta 0 (= 32 pixels) into two. The result of having generated the adaptation grid expression is shown and drawing 9 , drawing 10 , and drawing 11 the grid expression in each recursive depth (a) The result (smooth shading) of having carried out shading processing for the approximation polygon using the normal restored in a wire frame (adaptation mesh) display, (b) polygon approximation (flat shading) display, and (c) each lattice point is shown.
[0027] In this experiment, the numbers of the lattice points in each recursive depth 1, depth 2, and depth 3 (lattice point **total generated for = last adaptation lattice point **used / near configuration retrieval) were 1083/2386 point, 1670/4751 point, and 2483/9224 point, respectively. As shown in Table 1, computation time was the recursive depth 1, depth 2, and depth 3, and was 8 seconds, 13 seconds, and 28 seconds, respectively.
[0028]
[Table 1]

#facet / quad	size of facet (length of bese side)	Face 12				Face 5			
		depth	#nodes used/total	#facets	time	depth	#nodes used/total	#facets	time
2^2	Δ_0	0	620/1202	1102	5	0	642/1230	1130	5
2^3	$\Delta_0/\sqrt{2}$	1	1083/2386	2008	8	1	1155/2429	2129	8
2^4	$\Delta_0/2$	2	1670/4751	3142	13	2	1738/4820	3245	13
2^5	$\Delta_0/2\sqrt{2}$	3	2483/9224	4749	28	3	2429/9023	4591	29

[0029]
[Table 2]

#facet / quad	size of facet (length of bese side)	Face 12			Face 5		
		#nodes	#facets	time	#nodes	#facets	time
2^3	$\Delta_0/2\sqrt{2}$	5146	9618	35	5194	9655	37

[0030] As compared with the result of having used the superlattice of Table 1 and Table 2, the lattice point and the number of triangular patches (**facets) are decreased to about 47%, and it can check that the same precision (polygon approximation expression) has been attained.

[0031] In addition, although the above-mentioned example explained the case where a depth map was used, it can apply also to accommodative compression and restoration of common images, such as a shade image and a color picture, without restricting to this.

[0032]

[Effect of the Invention] As mentioned above, according to this invention, it can be based on that geometric property, the whole arbitration image can be compressed and restored accommodative, and it can use with high precision efficiently in fields, such as pictorial communication.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the outline block diagram of one example of this invention.
[Drawing 2] It is drawing showing the two-dimensional array of the tetragonal lattice element of initial grid width of face.
[Drawing 3] It is drawing showing the condition that the clad occurred in the approximation polygon obtained from a grid expression.
[Drawing 4] It is drawing for explaining the near retrieval range required in order to divide each grid element.
[Drawing 5] It is drawing showing the process which forms 2 adjoining grid elements in the binary tree structure of a three-stage.
[Drawing 6] It is drawing showing the succession regulation of the 3 lattice points of a parent triangle, and the middle point of **** accompanying generation of a child triangle.
[Drawing 7] It is drawing showing the condition of having described the configuration of a face image.
[Drawing 8] It is drawing showing the configuration restoration result using an initial grid.
[Drawing 9] It is drawing showing the configuration restoration result using 2 division adaptation grid.
[Drawing 10] It is drawing showing the configuration restoration result using a quadrisection adaptation grid.
[Drawing 11] It is drawing showing the configuration restoration result using 8 division adaptation grid.
[Description of Notations]
1 Superlattice Generation Equipment
2 Grid Initialization Equipment
3 Near Configuration Retrieval Equipment
4 Grid Division Equipment
5 Grid Expression Generation Equipment

[Translation done.]

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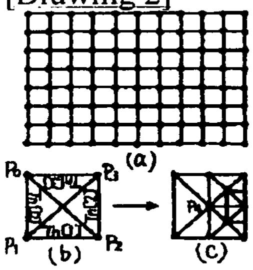
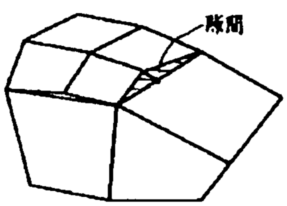
DRAWINGS

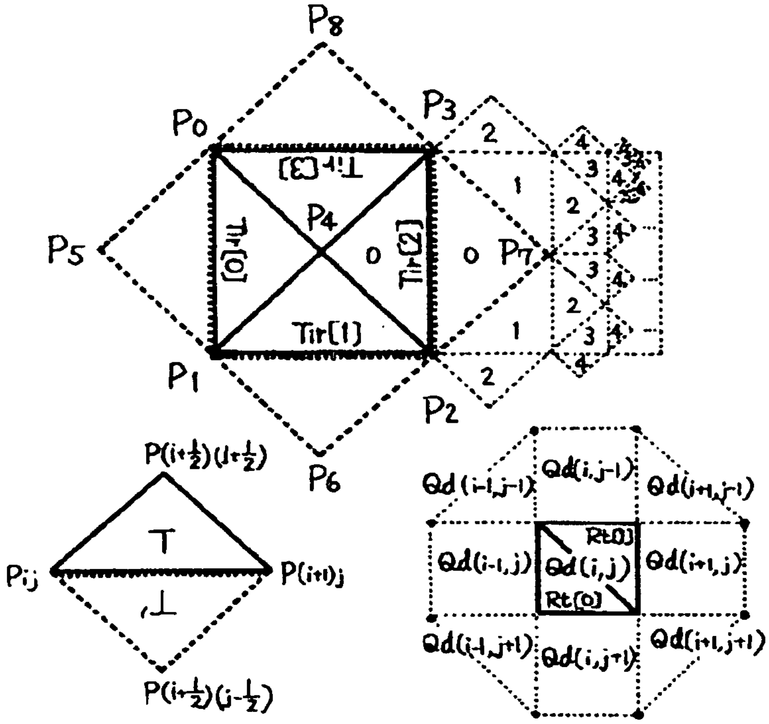
[Drawing 2]



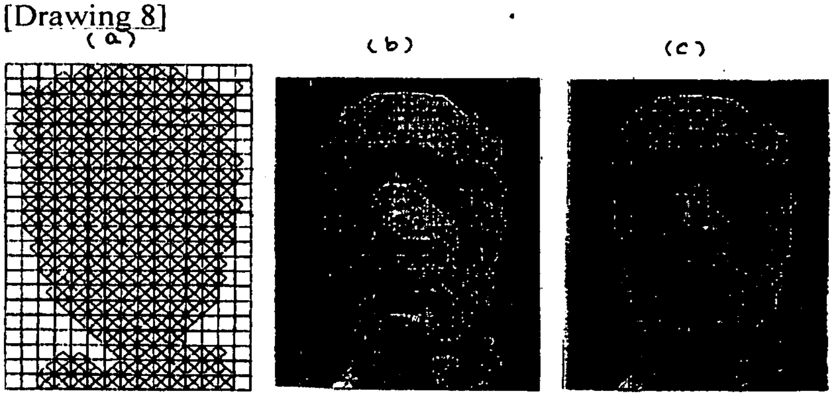
[Drawing 3]



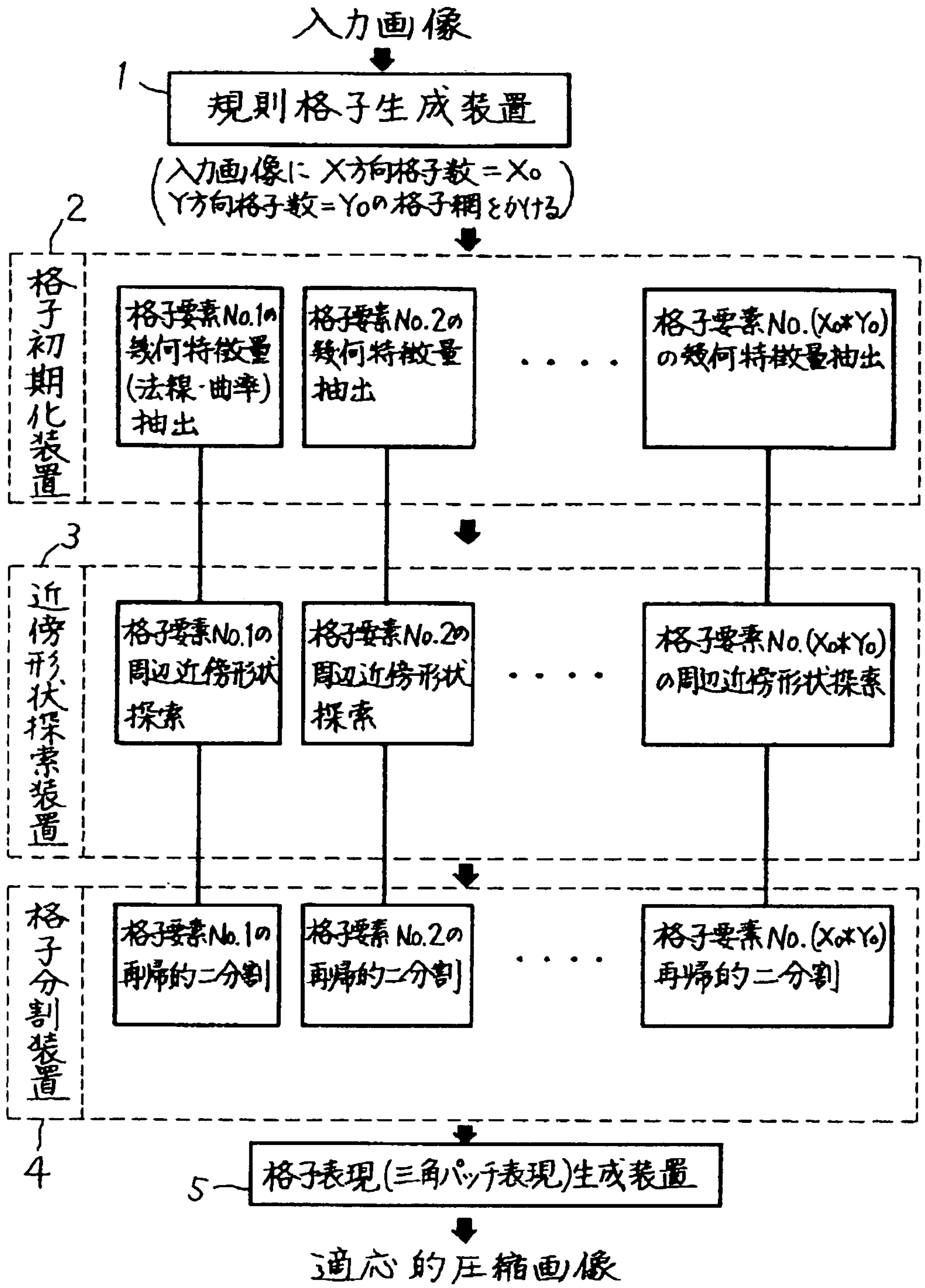
[Drawing 4]



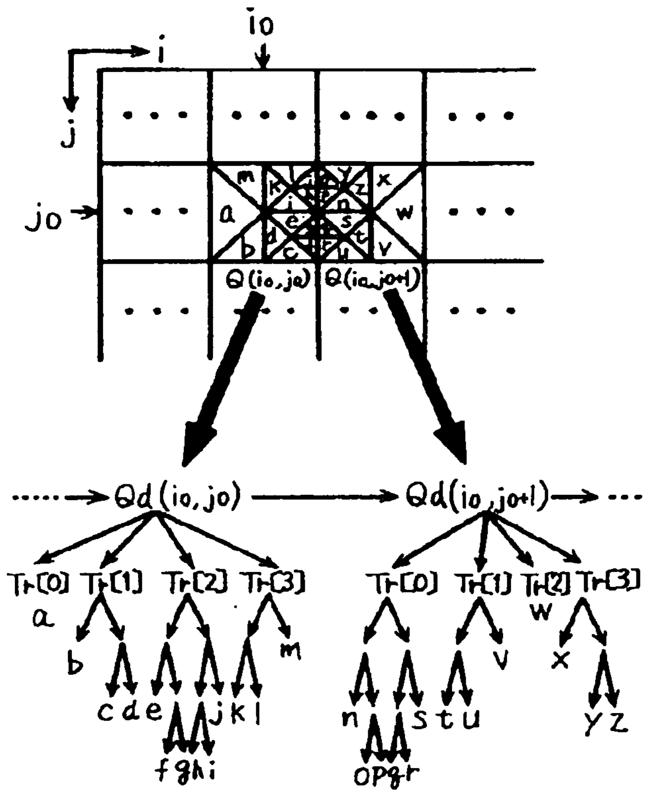
[Drawing 8]



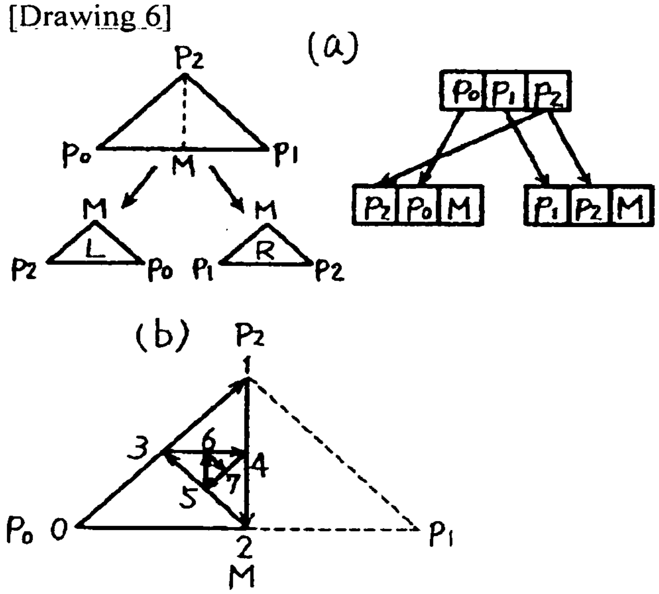
[Drawing 1]


入力画像
1
規則格子生成装置
(入力画像に X方向格子数＝Xo
Y方向格子数＝Yoの格子網をかける)
2
格子初期化装置
格子要素No.1の幾何特徴量(法線・曲率)抽出
格子要素No.2の幾何特徴量抽出
格子要素No.(Xo*Yo)の幾何特徴量抽出
3
近傍形状探索装置
格子要素No.1の周辺近傍形状探索
格子要素No.2の周辺近傍形状探索
格子要素No.(Xo*Yo)の周辺近傍形状探索
格子分割装置
格子要素No.1の再帰的二分割
格子要素No.2の再帰的二分割
格子要素No.(Xo*Yo)再帰的二分割
4
5
格子表現(三角パッチ表現)生成装置
適応的圧縮画像

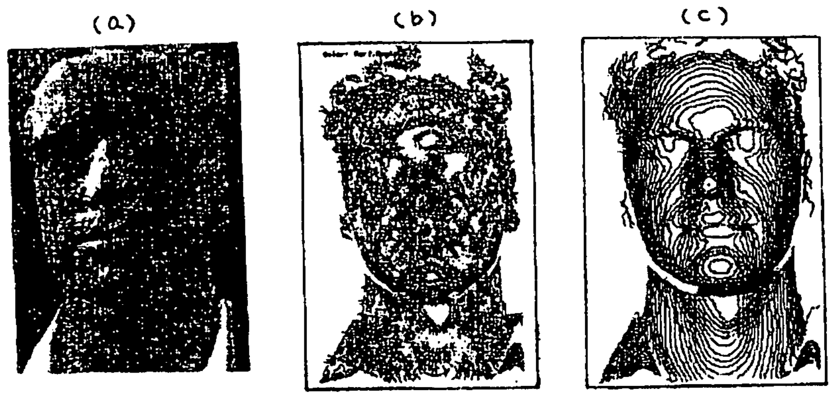
[Drawing 5]



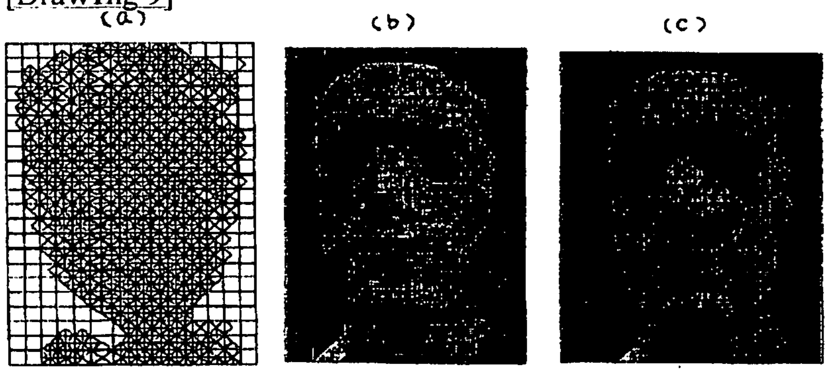
[Drawing 6]



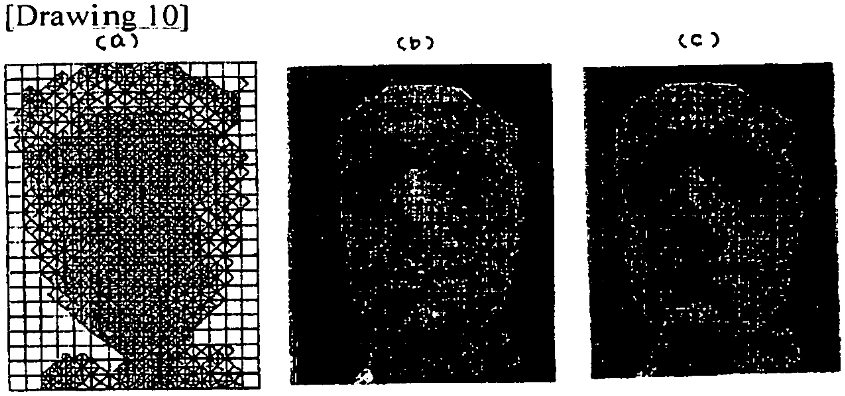
[Drawing 7]



[Drawing 9]

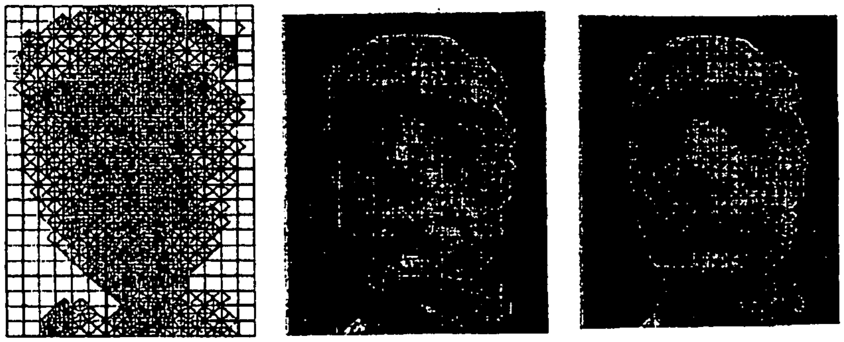


[Drawing 10]



[Drawing 11]

(a) (b) (c)



[Translation done.]